Next-Generation Fast Tuner for the Rare Isotope Ion Accelerator

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Superconducting RF accelerating cavities have been used for over 30 years to accelerate particle species from electrons, to heavy ions, up to uranium. We are designing an operational electromagnetic fast tuner that would advance the present state of the art.

In heavy-ion superconducting accelerators, where a large range of elemental ions are accelerated, beam currents are typically low, which makes these machines susceptible to detuning, resulting from mechanical vibrations collectively called microphonics. To mitigate these effects, an electromagnetic circuit that fast-switches the load impedance for reactive power stored in a transmission line can be coupled to a cavity to compensate the original detuning. Technology-base funds were used for an operational electromagnetic fast tuner that would advance the present state of the art.

By pursuing design concepts that used either an over-designed RF system, or a smaller, better-matched RF system that used fast tuners, we were able to show that using the fast tuner would reduce the installed RF power by 65 to 75% on a major nuclear physics accelerator, which would reduce the installed RF system costs by 35%, an appreciable savings at 6 to 16 $M.

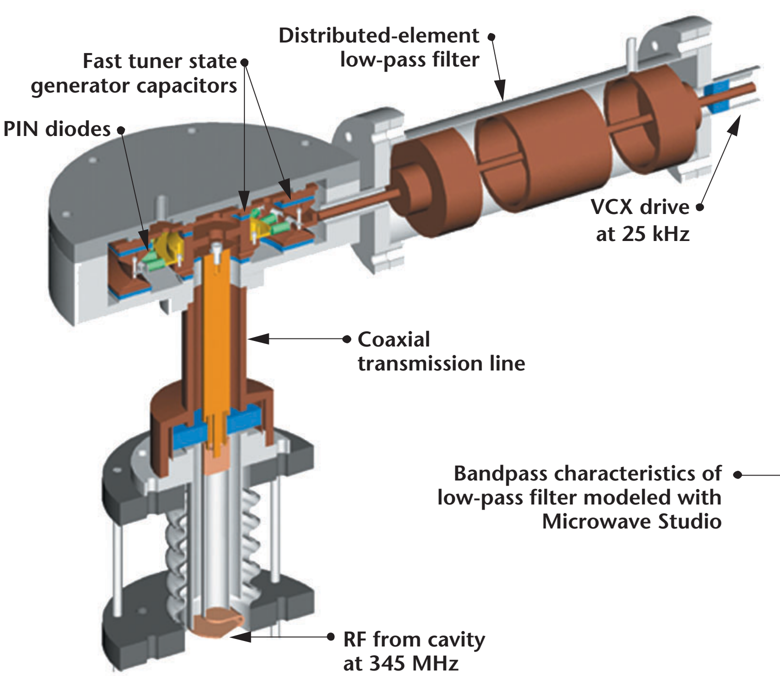
Advancing the design for the fast tuner beyond the state of the art that is currently operational at the ATLAS heavy-ion accelerator at Argonne National Laboratory required increasing the reactive power handling capability and operational frequency of the device. Due to the extent that each phase extrapolated the technology, the development process at that point was divided into two phases, both based on the distributed-element transmission line concept shown in the figure.

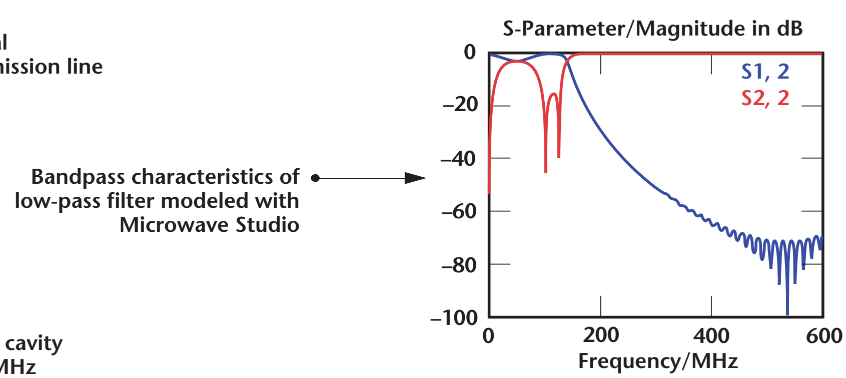
In the first phase, we aim to establish the feasibility of the transmission line design to increase power handling by 50% and frequency by 350%. The second phase would take the concept up a factor of 10 in power and a factor of 8 in frequency over what is available today.

The distributed-element design was created to allow the capacitive-dominated impedance state at the end of the coaxial transmission line to change at 25 kHz. The design shown in the figure combines the essential elements for fast-tuning the cavity-tuner system.

After the tuner was mechanically designed, electromagnetic and RF modeling was done to fine-tune the design to operate properly at the desired frequencies. We used Microwave Studio, a state-of-the-art 3-D electromagnetic modeling design code. An example of the modeling work is the distributed-element low-pass RF filter that allows the 25-kHz signal to reach the PIN diodes while keeping the main RF frequency of 345 MHz from being transmitted out.

If this design proves workable, it will be of interest to researchers in high-gradient, lightly-beam-loaded superconducting cavities, since it would give them a design option for making their RF system designs more robust and cost effective.





Mechanical design of fast-tuner assembly; coaxial transmission line with magnetic field coupling loop; and low-pass filter, with bandpass characteristics of the filter as modeled.